SECTION 429

TRAFFIC SIGNAL CONTROLLERS

429.1 GENERAL: This work shall consist of furnishing and installing traffic actuated controllers, special auxiliary control equipment, and cabinets in compliance with the specifications, details shown on the plans, and Standard Drawings at the locations shown on the plans, or as established by the ENGINEER.

429.2 REFERENCES.

429.2.1 Manual on Uniform Traffic Control Devices (MUTCD), Latest Edition

429.2.2 National Electrical Code (NEC), Latest Edition

429.2.3 National Electrical Manufacturers Association (NEMA)Standards, Latest Edition

429.3 MATERIALS.

429.3.1 TRAFFIC-ACTUATED CONTROLLER

429.3.1.1 General.

429.3.1.1.1 These specifications together with the NEMA Standards Publication TS-1-1989 or latest edition for Traffic Control Systems describe required features, functions, and test procedures for traffic actuated controllers. These specifications shall be considered in addition to the minimum requirements for a NEMA controller. All controllers furnished shall be of a modular design microprocessor type, unless otherwise called for on the plans or special provisions.

429.3.1.1.2 All input/output electrical connections for all standard and special functions shall be multi-terminal, MS type plugs on the front of the controller, conforming to the latest NEMA interface standards. (RS-232-C ports may be used for communications and special functions).

429.3.1.1.3 All controllers shall meet all requirements for a solid state NEMA traffic actuated controller and shall utilize the latest state-of-the-art design employing microprocessor and CMOS logic circuitry.

429.3.1.1.4 All controllers shall use a keyboard for entry of all operator timing and functional data into nonvolatile memory. The keyboard shall be of a type providing tactile feedback when depressed. The procedure required to enter, revise and display operator data shall be menu driven and designed to minimize the number of key strokes; all key functions shall be marked on the front of the controller, clearly and easily readable by the operator. The display shall be LCD with adjustable contrast and back lighting. The operator data shall be retained in memory for a minimum of 30 days after removal of primary power.

429.3.1.1.5 All controllers shall be capable of being programmed in different patterns of phase sequences: quad-left (NEMA), sequential, or combination of concurrent and sequential. All controllers shall permit programming of phases as inactive. The signal plan shall be pre-programmed by the manufacturer as called for on the plans. This signal plan (sequence, inactive phases, any overlaps, and/or preempt sequences) shall be nonvolatile (not held exclusively in RAM). All programmed data shall be retained in non-volatile EEPROM. In addition, battery backup shall be provided in the same module for the purpose of power down clock operation and battery backed RAM for non-programmed data, such as message logs.

429.3.1.1.6 All controllers shall be of modular design consisting of a main processor board (MPU) input/output interface, and the power regulation. The power transformer and capacitors may be rigidly fixed to the frame. Modules may be directly removable from the front of the controller. The keyboard and LCD displays shall be on the front of the controller. Provisions shall be made in the design to allow time base coordination and preemption programming through the controller keyboard.

429.3.1.1.7 All controllers shall be furnished with a front panel mounted RS 232-C industry standard input/output port. This port shall be capable of printing out program data to a stand alone printer; direct interface with a personal computer for uploading and downloading program data; and direct interface with a dial-up modem for remote communications with a personal computer over telephone lines. These connections shall be done such that there is no interruption to the signal operation.

429.3.1.1.8 All controllers shall have LCD alpha-numeric displays for timing, status and programming information. Each ring shall be provided with a separate display (simultaneous dual ring display). The display shall have two modes of operation (run and program). In the run mode, current phase, interval and interval time remaining shall be displayed. In the programming mode, the phase, interval or programmable function, and the time or value

shall be displayed. The controller shall permit the display of an operator-entered time or value before entering into memory, and shall provide for the automatic sequencing through the programming to minimize the required key strokes. It shall be possible to enter a four digit numeric security code to prevent unauthorized changes under the programming mode. Access to stored information shall be available at all times.

429.3.1.1.9 Internal preemption shall be furnished for all controllers, providing railroad and/or emergency vehicle preemption sequences. Preemption shall provide as a minimum, six independent preemption programs. It shall be possible to prioritize preemption, delay before preemption, cycle during preemption by hold phase assignments, and provide for pedestrian clearance through initial clearance yellow. All intervals to preemption shall be timed and all operator data shall be programmed through the controller keyboard. All operator-entered preempt data shall be made available on the printer hard copy. The furnished preempt sequencing and operation shall be as called for on the plans. All railroad preemption shall be in conformance with MUTCD requirements and include a track clearance phase. Return to normal controller operation shall be in accordance with the plan phasing diagram and a detector call shall be placed on phases as noted.

429.3.1.1.10 Internal time base coordination shall be furnished for all controllers providing the synchronization and control functions for coordinating actuated signalized intersections without the use of interconnecting cables. Coordination shall be made on a time of day, day of week and week of year basis. The coordinator shall function as a standard signal system coordinator using Force Offs, Holds and Phase/Ped Omits outputs and phase green inputs, capable of supervising the controller. The coordinator shall keep to the accuracy of the AC line frequency, and without line voltage to accuracy of at least +.005% (+50 ppm). The battery backup shall maintain real time and memory for at least 720 hours. The time clock shall keep track of time of day in seconds, day of week and week of year. It shall be possible to program for automatic Daylight Saving Time changes. In the event of a power disruption, the coordinator shall automatically upload itself upon return to line voltage. The coordinator shall have the minimum availability of 160 program changes, selectable on the minimum basis of 10 daily program groups, two weekly programs, and 10 exception day (holiday) programs. The program change (on or off of any single function) shall be selectable at least to a minute of any hour of a day. The coordinator shall have minimum selectable system options of 4 cycles, 4 splits per cycle, 3 offsets per cycle, 3 permissive periods per split, one pedestrian permissive period per split, and 3 force offs per split. Cycle settings shall be selectable from 0 to 255 seconds in one-second increments, or as a percentage of the cycle length. Offsets, permissive periods, and force off points may be programmable from 0 to 255 seconds in one-second increments or as a percentage of the cycle length. Offset seeking shall be selectable for dwell or shortway offset transitions. It shall be possible to manually select any program. The coordinated phase(s) shall selectable and shall be programmed as called for on the plans. Display(s) shall be provided to allow the user (with keyboard control) to display the current time of day, week of year, cycle countdown, current plan in effect, hold, force off, sync outputs, and all programmed data as they occur.

429.3.1.2 GENERAL DESIGN REQUIREMENTS

429.3.1.2.1 COMPONENTS

429.3.1.2.1.1 All timing circuits shall consist entirely of solid state electronic circuitry consistent with the state-of-the-art large scale integration circuit (LSI) techniques. The CONTRACTOR shall furnish cross reference and data sheets showing the parameters of all solid state devices used.

429.3.1.2.1.2 All switching functions shall be accomplished through the use of solid state electronic circuitry. No electromechanical devices, such as rotary, stepping, or line-switches, or time/break relays, shall be used for switching functions.

429.3.1.2.1.3 All printed circuit boards (assemblies) shall be of glass epoxy, two-ounce copper circuit traces, conforming to NEMA requirements for traffic signal controllers. Current carrying traces shall be covered with a solder mask material, and those boards containing a major number of CMOS components shall be coated with a humidity sealant. In addition, circuit reference designation for all components shall be clearly marked immediately adjacent to the component.

429.3.1.2.1.4 All components shall be amply derated with regard to heat dissipating capacity and rated voltage so that with maximum ambient temperature and maximum applied voltage, material shortening of life or shift in values shall not occur.

429.3.1.2.1.5 The design life of all components under 24 hour-a-day operating conditions in their circuit applications shall not be less than five years.

429.3.1.2.2 CONSTANCY OF INTERVALS: Constancy of Intervals. The controller shall be of such design that the length of any interval, portion, period, or unit extension may be set to two significant digits and will

be and remain within ±100 milliseconds of that setting if the line voltage is at any value from 95 volts to 135 volts, the ambient temperature is between -30 degrees F and +165 degrees F, and the line frequency is 60 hertz plus or minus 0.3 hertz. This performance shall include cold and hot starts and shall be obtained without the use of power-consuming heating or cooling apparatus of any kind.

429.3.1.2.3 POWER: The controller and all associated equipment shall be designed for use on 115-volt, 60-cycle, single phase AC.

429.3.1.2.4 MECHANICAL CONSTRUCTION.

429.3.1.2.4.1 The controller shall be housed in either a sheet aluminum, steel, or approved housing with a durable finish.

429.3.1.2.4.2 The controller shall be modular by design, conforming to microprocessor type specification.

429.3.1.2.4.3 Printed circuit boards shall be designed to plug into receptacles within the controller.

429.3.1.2.4.4 Printed circuit boards shall be provided with secure fastening devices to prevent falling out during transportation or handling.

429.3.1.2.4.5 All assemblies shall be interchangeable between controllers of the same manufacturer and series.

429.3.1.2.5 ENVIRONMENTAL: All controllers shall conform to NEMA Standards for Environmental, Interface, and Functional Requirements.

429.3.1.3 CONTROL REQUIREMENTS.

429.3.1.3.1 GENERAL: Operator timing and functional programming shall be accomplished on the front panel of the controller. Programmed NEMA overlap boards may be inserted in a slot provided on the front panel or internally within the controller. Operator programming shall be by digital switches or keyboard entry, consistent with these specifications.

429.3.1.3.2 PHASE TIMING: The following timing intervals shall be provided for each traffic phase. The interval and minimum range of adjustment of the timing intervals shall be:

INTERVAL	TIMING RANGE (SECONDS)	MAX RESOLUTION (INCREMENTS)
Minimum	0-99	1
Extension (Gap)	0-9.9	0.1
Yellow Change	0-9.9	0.1
Red Clearance	0-9.9	0.1
Maximum (MAX 1)	0-99	1
Maximum (MAX 2)	0-99	1
Walk*	0-99	1
Ped. Clearance*	0-99	1
Red revert**	2-7	1

* Need be furnished with each through traffic movement phase only.

**Per controller or ring; may be internal setting.

429.3.1.3.3 PHASE CONTROL FUNCTIONS: Each phase shall be capable of being set to the following functions:

429.3.1.3.3.1 MAX RECALL (NON ACT): automatically returns phase and extends green timing to that of MAX GREEN. In absence of opposing phase demand, the controller shall rest in GREEN.

429.3.1.3.3.2 PED RECALL (NON ACT): automatically returns phase to WALK-PED CLEARANCE and vehicle right of way without vehicle and Pedestrian demand.

429.3.1.3.3.3 VEH. RECALL (EXT.): automatically places a recurring demand for vehicle service without actual vehicle demand when not in its green interval.

429.3.1.3.3.4 NON LOCKING (MEMORY OFF): phase operates in fully actuated mode; memory of vehicle demand is retained only when a vehicle is in the detection zone (detector outputting).

429.3.1.3.3.5 LOCKING (MEMORY ON): phase operates in fully actuated mode; memory of vehicle demand (detector output) is retained in the phase until that phase is served.

429.3.1.4 OPERATIONAL REQUIREMENTS

429.3.1.4.1 TIMING REQUIREMENTS

429.3.1.4.1.1 The clearance period shall consist of time intervals of preset duration, namely:

(1) Yellow Change Interval.
(2) Red Clearance Interval.

429.3.1.4.1.2 Each phase shall be provided with an initial interval control determining the guaranteed minimum green period for that phase. With a pedestrian actuation or a pedestrian and vehicle actuation, the minimum green shall consist of the sum of the walk interval and pedestrian clearance interval or minimum green interval, whichever is greater.

429.3.1.4.1.3 Each phase shall be provided with an extension interval control which shall provide vehicles added green time beyond the minimum green time by vehicle actuation(s). Successive actuations shall cancel the remainder of the previous extension interval and shall initiate a complete new extension interval for the vehicle which provided the actuation. Should transfer of right of way occur while an extension interval is unexpired, the right of way shall be returned at the next opportunity in the cycle.

429.3.1.4.1.4 Each phase shall contain two maximum green timing interval controls which shall set a limit on the length of time that continuous traffic on the right of way phase can extend the right of way for that phase after an actuation is registered for any conflicting phase. Normal operation shall be in the (MAX 1) maximum interval. The second (MAX 2) maximum interval shall be effected by both an external and internal input.

429.3.1.4.1.5 Actuation of a pedestrian push button during a pedestrian clearance interval or at any other time while the pedestrian "Don't Walk" signal is being displayed shall register the presence of said pedestrian. This actuation shall be remembered so that the pedestrian walk indication will be accorded at the next assignment of right of way to the phase.

429.3.1.4.1.5.1 In the event of a registered pedestrian actuation on a phase with no demand for pedestrian or vehicular right of way on a conflicting phase, the phase shall be capable of recycling and providing pedestrian and pedestrian clearance intervals.

429.3.1.4.1.5.2 The minimum and guaranteed pedestrian protection shall consist of the pedestrian clearance interval. During the balance of the right of way and clearance intervals the "Don't Walk" shall be steady.

429.3.1.4.2 PHASING REQUIREMENTS

429.3.1.4.2.1 Right of way shall not be given to any street without an actuation (call) and, in complete absence of traffic (or recall option), right of way shall remain on the street where it was last assigned unless RED REST option has been exercised; then the controller shall cycle to all red and remain until a phase call.

429.3.1.4.2.2 All controllers shall operate as a concurrent phase timing (dual ring) controller, or sequential (single ring) configuration. All phases shall be identified (numbered) and operate in accordance with a NEMA dual ring (quad-left) configuration or sequential configuration. All controllers furnished shall be capable of operating eight field phases. Controllers shall be capable of assigning the right of way to a single phase or any combination of non-conflicting phases, and shall normally operate in the mode specified on the plans. Phases skipped on each ring for no demand and recall functions for each phase shall be as specified for sequential controllers. Controllers shall have the capability of providing four overlap phases in any phase combination, programmable on both a standard NEMA plug-in overlap program board and operator keyboard entry.

429.3.1.4.3 All controllers shall have all input/output features per phase, ring and unit as required under NEMA Standards. Any unused inputs/outputs shall be wired to and identified on the controller back panel.

429.3.1.4.4 All controllers shall have an initialization control to start at the beginning of the programmed GREEN, YELLOW, or RED interval of the selected phase(s), as called for on the plans, application of power or the EXTERNAL START input. Vehicle and pedestrian calls shall then be placed on phases.

429.3.2 SYSTEM MASTER

429.3.2.1 A system master shall be a traffic adjusted system master (arterial or multi system as specified) of a microprocessor or computer design. When specified on the plans, peripheral equipment, communication equipment and/or a cabinet shall be part of this item. The exact location shall be as called for on the plans. All system masters shall conform to the design, operational, and communication requirements called for on the plans and/or special provisions.

429.3.2.2 All units shall be shelf mounted in the controller cabinet with MS or RS-232 type connectors, and shall be housed in a metal cabinet; conforming to this Section 429.

429.3.3 CABINETS, SUPPORT EQUIPMENT, AND WIRING

429.3.3.1 GENERAL

429.3.3.1.1 Unless otherwise specified on the plans the components of the controller shall be provided in a sturdy, weatherproof metallic housing hereinafter referred to as a

controller cabinet

429.3.3.1.2 Unless otherwise specified on the plans, all cabinets shall be wired for the full application of all phases, pedestrian signals on all through movements, and all normal overlaps for either four phase-single ring operation, or eight phase-dual ring operation. All vehicle detection shall be wired. The cabinet shall be furnished so that to implement any initially unused phases or functions, it shall only be necessary to add load switches, vehicle detectors, disconnect any jumpers and rearrange field conductors.

429.3.3.1.3 All ground mounted cabinets shall be #14 gauge sheet steel or 0.125 inch minimum thickness type 5052-H32 aluminum. Pedestal cabinets shall be aluminum of 0.125-inch minimum thickness cabinets shall be designed and manufactured for rigid mounting whether intended for pole or pedestal mounting. The cabinets shall not flex on their mounts. The specific types of controller cabinets and their internal components and wiring arrangements for a particular installation shall be as necessary to provide a complete operating traffic control system as called for on the plans or in the special provisions, and as follows:

429.3.3.1.3.1 The cabinet shall have a main door which shall be equipped with a Corbin tumbler lock number 1548-1 and an auxiliary door equipped with a treasury type lock Corbin Number R357SG5 for a police key. The main door handle shall have provisions for padlocking in the closed position.A rain channel shall be incorporated into the design of the main door opening to prevent liquids from entering the enclosure. The cabinet door must be a minimum of 80% of the front surface of the cabinet. A stiffener plate shall be welded across the inside of the main door to prevent flexing. The top of the cabinet shall incorporate a slope toward the rear to prevent rain accumulation. All seams shall be sealed with RTV sealant or equivalent material on the interior of the cabinet. The main door and police door-in-door shall close against a weatherproof and dust proof closed cell neoprene gasket seal. The lower section of the cabinet door shall be equipped with a louvered air entrance. The air inlet shall be at least 16 inches by 20 inches in size. Louvers must satisfy the NEMA rod entry test for 3R ventilated enclosures A non-corrosive, vermin and insect proof, removable air filter shall be secured to the air entrance. The filter shall fit snugly against the cabinet door wall. The main door hinge shall be a one piece, continuous piano hinge with a stainless steel pin running the entire length of the door mounted on the right side when facing the cabinet. The hinge shall be attached in such a manner that no rivets or bolts are used.

429.3.3.1.3.2 Substantial metallic shelves or brackets to support the controller and auxiliary equipment shall be furnished and installed. A minimum of two (2) shelves shall be provided, unless approved otherwise. The shelves shall be adequately supported at both ends by angle-type braces. The shelves shall be of sufficient strength to prevent the shelf from sagging with the full weight of the control equipment.

429.3.3.1.3.3 Control cabinets shall be of sufficient size to allow the controller assembly and all associated equipment to stand in an upright position on the shelving. No equipment shall be placed on the floor of ground mounted cabinets. The control cabinet shall be of sufficient size to allow the removal of the controller assembly by pulling this assembly straight out. It shall not be necessary to turn the assembly sideways to remove it from the cabinet. The cabinet shall be of sufficient size to allow the door to be closed with no interference to the wire harness running to the door. All equipment and wall mounted devices shall be capable of being removed without relocating or unjacking one device to another device. Cabinet wiring shall be such that the front panels of control equipment are not obscured.

429.3.3.1.3.4 The minimum acceptable cabinet size shall be as follows or as specified on the plans or in the special provisions, provided that the above mentioned space requirements are met:

TYPE OF CAB.	OUTSIDE DIMENSIONS HxWxD	USE
G	33" X 20" X 14"	When called for on plans
M	48" X 30" X 16"	When called for on plans
MSX	57" X 30" X 17"	When called for on plans
P	54" X 38" X 24"	4-Phase single ring operation
P	54" X 38" X 24"	8-phase dual ring operation
R	72" X 38" X 24"	When called for on plans

429.3.3.1.3.5 All cabinets for controllers shall be of the ground mount type with internal bolts, unless otherwise called for on the plans. Anchor bolts and templates for their installation shall be shipped as soon as possible to the CONTRACTOR so that the necessary concrete base may be installed in advance of receiving the controller.

429.3.3.1.3.6 All cabinets shall be finished as follows:

a. Steel Cabinets, Inside and Outside.

First Coat. Flow Stage Iron Phosphate coating
Second Coat. TGIC Polyester Power
Coat paint matching Federal Standard 595A
Color Chip 27886, with a minimum dry film

thickness of 2 mm.

b. Aluminum cabinets: No paint required.

c. Special projects: Finish either steel or aluminum cabinets as designated on plans.

429.3.3.2 CABINET WIRING, TERMINALS AND FACILITIES: These specifications together with NEMA Standards, describe the requirements for wiring, terminals and facilities within the cabinet.

429.3.3.2.1 CABINET WIRING

429.3.3.2.1.1 All cabinet wiring shall be neat and firm and all harness and cabinet wiring shall be laced or bound together with Ty wrap or equivalent.

429.3.3.2.1.2 All back panel wiring shall conform to the following gauge and color:

Grn/walk loadswitch out - brown wire	- 14 gauge
Yellow loadswitch out - yellow wire	- 14 gauge
Red/don't walk loadswitch out - red wire	- 14 gauge
CMU (other than AC pwr) - violet wire	- 22 gauge
Controller I/O - blue wire	- 22 gauge
AC+(pwr panel to main panel) - blk wire	- 8 gauge
AC+(main panel) - blk wire	- 10 gauge
AC-(pwr panel to main panel)- white wire	- 8 gauge
AC-(main panel) - white wire	- 10 gauge
Chassis ground (pwr panel) - green wire	- 8 gauge
DC ground - grey wire	- 22 gauge
Flash programming- orange wire	- 14 gauge

429.3.3.2.1.3 All wiring, 14 AWG and under, shall conform to MIL-W-I6878/I, type B/N, 00V, 19 strand tinned copper. The wire shall have a minimum of 0.010 inch thick PVC insulation with clear nylon jacket and rated to 105 degrees Celsius. All 12 AWG and larger wire shall be UL listed THHN/THWN 90 degrees celsius, 600 V, 0.020 inch, thick PVC insulation and clear nylon jacketed.

429.3.3.2.1.4 All connecting cables and wire runs shall be secured by mechanical clamps. Stick-on type clamps are not acceptable.

429.3.3.2.1.5 Logic ground and chassis ground shall be isolated from each other within the cabinet In addition, chassis ground and AC- shall not be tied together within the cabinet.

429.3.3.2.1.6 All wire at solder joints shall be hooked or looped around the eyelet or terminal block post prior to soldering to insure circuit integrity. Lap joint soldering is not acceptable.

429.3.3.2.1.7 All back panel, D interface panel, and detector panel terminal blocks should be permanently numbered and labeled as to their function.

429.3.3.2.2 BACK PANEL

429.3.3.2.2.1 A back panel shall be provided for termination of all DC logic wiring. This panel shall be located on the back of the cabinet below the equipment shelves and shall include the load bay and the flasher/flasher relays. All terminals and plug-in units shall be readily accessible without moving any equipment.

429.3.3.2.2.2 The back panel shall be a pre-wired type with the controller harness, conflict harness, and detector inputs permanently wired to the back of the panel. Connections for DC wiring shall be ¼-inch quick connect tab type, 300 Volt and 20 amp. rated, the wire being mechanically stripped ¼-inch and the tab firmly crimped covering wire and insulation, or soldered. All AC connections on the panel back and all connections to the load switch/flasher receptacles shall be soldered. All NEMA functions shall be brought out to the front of the panel with screw type connector. It shall be possible to program on the front, using jumpers (clips or wires), the signal outputs for all the types of phasing operations possible for the specified controller and to access all NEMA functions on the front for future auxiliary equipment. The terminal functions shall be clearly marked with the appropriate NEMA designation. When auxiliary equipment logic is called for on the plans, these connections shall be made on the front of the panel.

429.3.3.2.2.3 The panel shall be mounted to the cabinet so as to allow sufficient clearance between the cabinet wall and the panel's back connections. It shall be possible to drop the panel in the field (access back wiring) using simple hand tools. The load bay, including flasher, shall be a rack-mounted type. The load switches and flasher shall be adequately supported after insertion to prevent falling out due to vibrations.

429.3.3.2.2.4 The following minimum positions for plug-in units shall be provided:

TYPE OF CAB.	LOAD SWITCH POSITION	FLASH POSITION	RELAY NEMA FLASHER
4 phase single ring	8	2	1
8 phase dual ring	16	4	1

429.3.3.2.3 POWER DISTRIBUTION PANEL: The power distribution panel shall be provided on the lower

right-hand side of the cabinet and shall be fully enclosed with a removable cover to prevent accidental shock. The power panel shall include the main power feed terminal (barrier type), the required AC protection from lightning (EDCO SHP-300 surge arrestor or approved equal), filter (RFI), MOV to ground, and any NEC requirements.

429.3.3.2.4 DETECTOR PANEL

429.3.3.2.4.1 A detector panel shall be provided on the left-hand side of the cabinet.

429.3.3.2.4.2 Terminal blocks (barrier type), with removable buss bars shall be provided for all detectors and pedestrian push-button field conductors as required on the plans. The detector rack shall include the "J" pin conductor appropriately terminated for extend/delay operation.

TYPE OF CABINET	DETECTOR RACK POSITION	DETECTOR TERMINAL BLOCKS
4 phase single ring	16	20
8 phase dual ring	16	32

8 PHASE DUAL RING OPERATION
16 POSITION DETECTOR RACK
(MINIMUM FOR EACH CABINET)
U=Unit

U 1	U 2	U 3	U 4	U 5	U 6	U 7	U 8
PH1	PH2	PH6	PH2EC	PH3	H4	PH8	PH4EC
PH5	PH2	PH6	PH6EC	PH7	PH4	PH8	PH8EC

U=UNIT

SYSTEM DETECTORS & PREEMPTION

U 9	U 10	U 11	U 12	U 13	U 14	U 15	U 16
SD1	SD3	SD5	SD7	SD9	PED	EVP1	EVP3
SD2	SD4	SD6	SD8	SD10	ISO	EVP2	EVP4

U=UNIT

4 PHASE SINGLE RING OPERATION
8 CHANNEL DETECTOR RACK
(MINIMUM FOR EACH CABINET)

U 1	U 2	U 3	U 4	U 5	U 6	U 7	U 8
PH1	PH2	PH4	PH2EC	SD1	SD3	PED	EVP1
PH3	PH2	PH4	PH4EC	SD2	SD4	ISO	EVP2

U=UNIT

429.3.3.2.4.3 Connector/Pin assignments (2x22 pin edge card connector with 0.156 inch contact centers, key slots located between B & C and M & N) shall be as follows:

A = DC (-) Common
1 = Call Delay Inhibit (Channel 1)
B = DC (+) Power
2 = Call Delay Inhibit (Channel 2)
C = Reset
4 & D = Loop #1
5 & E = Loop #1
F = Output #1A Optocoupler (Collector)
H = Output #1A Optocoupler (Emitter)
8 & J = Loop #2
9 & K = Loop #2
L = Chassis Ground
S = Output 1B AccuCount FET (Drain)
W = Output #2A Optocoupler (Collector)
X = Output #2A Optocoupler (Emitter)
Y = Output #2B AccuCount FET (Drain)
Z = Output #1C Fail FET (Drain)
19 = Output #2C Fail FET (Drain)

All pins not listed are spares.

429.3.3.2.5 "D" CONNECTOR PANEL: A "D" connector panel with harness shall be provided with each cabinet assembly on the left hand side of the cabinet, fully wired to provide all functions. All terminal blocks shall be barrier type. The panel shall contain provisions for mounting two (2) 120 volts AC relays for preempt inputs 1 and 2, and 1/4 AMP fuses for each relay.

429.3.3.2.6 TERMINALS: All terminals shall be numbered and identified with nomenclature that corresponds to the nomenclature on the controller assembly wiring diagram.

429.3.3.2.7 TELEMETRY INTERFACE

429.3.3.2.7.1 A telemetry interface harness and printed circuit board interface panel shall be supplied with each cabinet assembly. All terminal blocks shall be barrier type. As a minimum, the following input/output shall be accessible from the telemetry interface panel.

Local Controller Command Lines 1 & 2.
Local Controller Read Back Lines 1 & 2.
Master Controller Command Lines 1 & 2.
Master Controller Read Back Lines 1 & 2.
Chassis Grounds.
Four Special Function Outputs.
Eight System Detector Inputs.
Flash Input.
CMU Flash Input.

429.3.3.2.7.2 A socket mounted communication line transient protection device shall be supplied with the

telemetry interface panel. The transient protection device shall be wired in series with the telemetry communications circuit.

429.3.3.2.7.3 Communication line impedance shall be matched to the transmitter output impedance to minimize noise on the line.

429.3.3.2.8 SYSTEM MOV RATING: When a system master is called for, MOV rating shall be provided on the DC outputs (controller inputs) when not provided internal to the unit.

429.3.3.2.9 WIRING DIAGRAMS

429.3.3.2.9.1 Four sets of wiring diagrams (one shall be mylar type) shall be furnished for each cabinet. The cabinet shall be equipped with a plastic envelope to house one or more cabinet wiring diagrams. These wiring diagrams shall be furnished with the equipment submitted to the ENGINEER before testing will begin.

429.3.3.2.9.2 The cabinet wiring diagrams shall show and identify the connectors for all equipment and switches, relays, flashers, etc.

429.3.3.2.9.3 The diagrams shall also have a complete intersection sketch, with street names and north arrow including labeling of signal heads and detectors and a signal sequence chart identified and related to the intersection sketch.

429.3.3.2.10 ADDITIONAL ITEMS: The following additional terminals, protection devices, and switches shall be furnished for all cabinets:

429.3.3.2.10.1 A UL listed circuit breaker for filtered AC power serving all solid state devices including load switches, sized as follows:

(1) 40 AMP protection for four phase single ring assemblies.

(2) 50 AMP protection for eight phase dual ring assemblies.

429.3.3.2.10.2 A separate 20 AMP breaker for AC circuit serving the G.F.I. outlets, fan and light.

429.3.3.2.10.3 Terminal blocks (barrier type) for all AC+ connections.

429.3.3.2.10.4 Copper ground strip, mounted and ground to cabinet wall, for connection of all common conductors.

429.3.3.2.10.5 All field signal output circuits shall be terminated on an unfused barrier type terminal block with a minimum rating of 15 amps. AC field terminals shall have a number 10-32x7/16 inch screw as a minimum. All field input/output terminals shall be identified by permanent numerical marking strips. All field flash sequence programming shall be accomplished at the field terminals with the use of screwdriver only. Field terminal blocks shall be wired to use four positions per vehicle or overlap phase (green, yellow, red, flash). It shall not be necessary to debuss field terminal blocks for flash programming.

429.3.3.2.10.6 Terminal blocks (barrier type) shall be provided to terminate a special equipment harness. These terminals shall be located on the right-hand side of the cabinet, above the power distribution panel.

429.3.3.2.10.7 Terminals for connecting interconnect cable tie points and intercabinet termination when required. Transient protection (MOV with rating or as called for on the plans) shall be provided on all external lines.

429.3.3.2.10.8 One duplex G.F.I. convenience outlet shall be furnished for energization of test equipment, tools, and lighting. A second duplex G.F.I. convenience outlet, wired to filtered AC power, shall be furnished for telemetry equipment. The G.F.I. convenience outlets shall be NEMA type 5-15R.

429.3.3.2.10.9 Switches behind police auxiliary door.

429.3.3.2.10.9.1 Main switch, identified "On-Off," wired to turn off signal light power when switched to off position and to de-energize the controller and auxiliary equipment. This switch and connecting wiring, shall be rated at 50 AMP minimum.

429.3.3.2.10.9.2 Auto flash switch, identified "Auto Flash," wired to keep controller energized and to place signals on flash when switched to flash position. The controller shall have stop timing applied when in the flash position.

429.3.3.2.10.10 Interior Cabinet Switches.

429.3.3.2.10.10.1 The interior switches below and convenience outlet specified above shall be combined on a single panel and mounted on the back side of the cabinet door unless otherwise noted. All switches except main switch shall be heavy duty and rated 15 AMPS minimum. Momentary push buttons shall be rated at 1 AMP minimum for all vehicle and pedestrian inputs to the controller. Any exposed terminals or switch solder points shall be covered with a non-flexible shield to prevent accidental contact. All

switch functions must be permanently and clearly labeled. All wire routed to the police door and test push button panel shall be adequately protected against damage from repetitive opening and closing of the main door.

429.3.3.2.10.10.2 Test Switch. Two-position switch, identified "Auto Flash," wired to de-energize the signal light power when switched to flash position and to permit the controller to cycle through its normal sequences while displaying flash indications on signals.

429.3.3.2.10.10.3 Controller On/Off Switch. Two-position switch, identified "Controller On/Off," wired to de-energize the controller and auxiliary equipment when switched to the off position.

429.3.3.2.10.10.4 Vehicle and Pedestrian Detector Switches. Two position momentary switches labeled "ON TEST" wired to each vehicle and pedestrian detector input for permitting the substitution of manual call into each controller detector input. Identify switches as to phase/function.

429.3.3.2.10.10.5 Preemption Test Switches. Test switches shall be provided to permit a manual preempt input. Each preemption phase shall have a separate switch with each phase appropriately identified.

429.3.3.2.10.10.6 Conflict Monitor Door Switch. The cabinet shall include a switch that prevents a signal from full operation without the conflict monitor property connected to the cabinet harness.

429.3.3.2.10.10.7 Door Open Switch. The cabinet shall include a door switch to log an event to the system master that the door is open.

429.3.3.2.10.10.8 Fluorescent Light Door Switch. The cabinet shall include a door switch that turns the cabinet fluorescent light on when the cabinet door is open.

429.3.3.2.10.11 Radio line filter (RFI) for filtering AC+ lights and control power for solid state light control and controller operation.

429.3.3.2.10.12 Pedestrian push-button isolation (field circuit) shall be rack mounted to protect solid state devices from transient voltages, i.e., prevent transients from being induced in the open pedestrian push-button circuits by isolation transformer(s), or by optoisolation.

429.3.3.3 ADDITIONAL CABINET FEATURES

429.3.3.3.1 Cabinet Fan. A fan shall be mounted in the controller cabinet and shall be thermostatically controlled and shall turn on at a cabinet temperature manually adjustable through a range of 70 degrees F to 160 degrees F. The fan and cabinet vent holes shall be located with respect to each other so as to direct the bulk of the air flow over the controller unit. The inside opening shall be covered with ¼-inch maximum mesh screening to prevent the operator from accidentally coming in contact with moving fan blades. The cabinet intake fan vent here shall be filtered.

429.3.3.3.2 Fluorescent Light. A fluorescent fixture and lamp shall be mounted in the cabinet over the door, positioned so as to minimize damage when sliding equipment off shelves. The fluorescent fixture shall be for an F20T12 lamp in all ground mounted cabinets and for an F15T12 lamp in pedestal cabinets. The lamp shall be packaged separately when transported to avoid breakage. The fluorescent light shall be turned on by use of a door switch.

429.3.3.3.3 Door Stops. Each controller cabinet door which is 22 inches or more in width or 6 square feet or larger in area shall be provided with a stop to limit door opening to both 90 degrees and 180 degrees, plus or minus 10 degrees. The stop shall be provided with a catch which can be operated when the door reaches the extreme open position and which will hold the door open securely until released.

429.3.3.4 SOLID STATE SIGNAL AND PEDESTRIAN LOAD SWITCHES

429.3.3.4.1.1 All signal load switches shall be external to the controller and shall be carried in the back panel load bay.

429.3.3.4.1.2 In addition to this specification, all signal control load switches shall conform to NEMA Standards.

429.3.3.4.2 The signal control assembly shall consist of a separate plug-in unit containing control circuitry for the operation of three separate signal lamp circuits. Vehicle and pedestrian control assemblies shall be interchangeable. Any unused output of each control assemble shall not be used for any other function or phase.

429.3.3.4.3.1 Circuitry shall consist of solid state electronic components. No mechanical relays shall be used for the opening and closing of signal light circuits or for any other purpose.

429.3.3.4.3.2 The design life of all components under 24 hours per day operating conditions in their circuit application shall not be less than five years.

429.3.3.4.4 All load switches shall be rated at 20 AMPS.

429.3.3.4.5 Each load switch shall include three LED indicators on the face of the switch, visible through the door opening of the cabinet, and connected to the input functions.

429.3.3.5 SOLID STATE FLASHER

429.3.3.5.1 A solid state flasher, NEMA type 3, 20 amps per circuit, dual-circuit, shall be furnished with each controller cabinet. The flasher shall be rack-mounted in the back panel adjacent to the load bay. All solid state flashers shall conform to NEMA Standards.

429.3.3.5.2 The flasher transfer relays shall be the normally open, multi-contact plug type. A sufficient number of relays shall be provided to permit any combination of flashing red or yellow indications. One RC network shall be wired in parallel with each group of three flash transfer relays and any other relay coils. All flash transfer relay sockets shall be Cinch-Jones #2408SB or approved equal.

429.3.3.6 CONFLICT MONITOR (NEMA Plus).

429.3.3.6.1 A conflict monitor unit shall be furnished with each controller. All signal monitors shall be the self-contained, shelf mounted type with the appropriate NEMA MS connector(s). In addition to this specification, all conflict monitors shall conform to NEMA Standards.

429.3.3.6.2 Minimum monitor functions shall be as follows:

429.3.3.6.2.1 Conflicting GREEN, YELLOW or WALK signal indications at the controller assembly field terminals.

429.3.3.6.2.2 Detect the absence of a required RED signal indication at the field terminal when the GREEN or YELLOW inputs of that channel are not active. The red monitor point shall be made on the field side of the field output terminal.

429.3.3.6.2.3 Monitor the operating voltage in the controller unit and the + 24 volt DC inputs.

429.3.3.6.2.4 Simultaneous sensing of active GREEN and YELLOW or GREEN and RED signal indications on a channel. If either of these conditions exist for 700 milliseconds, the conflict monitor shall not trigger. If either of these conditions exist for 1000 milliseconds, the conflict monitor shall trigger.

429.3.3.6.2.5 Absence of an active YELLOW input for a preset period (2.0 to 2.8 second range) following the termination of an active GREEN input on a channel.

429.3.3.6.2.6 In the event of any of the above faults, the monitor shall apply stop timing to the controller unit and transfer the signals to a flashing operation.

429.3.3.6.2.7 Green or Walk vs. Yellow. When enabled, all channels will monitor for Green or Walk indications on at the same time as the Yellow for that same channel.

429.3.3.6.2.8 Green, Walk or Yellow vs. Red. When enabled, the corresponding channel will monitor for Green, Walk or Yellow indications on with the Red indication of the channel.

429.3.3.6.3 Manual reset shall be required following a conflict or sequence failure, or absence of red; to place signals in normal operation. Return to normal operation shall be automatic after a power supply fault or power outage, following a preset period of flashing operation. Flashing operation shall not be returned to normal operation if a conflict has been detected prior to a power interruption.

429.3.3.6.4 A cabinet interlock shall be provided indicating the presence of the monitor and causing a transfer to flashing operation if the monitor is disconnected.

429.3.3.6.5 Monitor shall include a LCD readout display with the minimum indicators required as follows:

a. Triggering of the conflict monitoring.

b. Triggering of the RED monitoring.

c. Triggering of the sequence monitoring.

d. Triggering of the +24V monitor portion #1.

e. Triggering of the +24V monitor portion #2.

f. Triggering of the controller voltage monitor.

g. One indicator per channel which displays an active GREEN, YELLOW or WALK input. This channel indicator shall latch with the triggering of the conflict monitor.

h. A RED failure. The channel indicator(s) in fault shall illuminate.

i. A sequence failure. The channel indicator(s)

in fault shall illuminate.

j. Green or Walk vs. Yellow.

k. Green, Walk or Yellow vs. Red.

429.3.3.6.6 Monitor shall be capable of recording fault history and generating reports.

429.3.3.6.7 Type of monitor to be furnished:

CABINET TYPE	MONITOR TYPE
4 phase single ring	NEMA Plus 6 Channel
8 phase dual ring	NEMA Plus 12 Channel

429.3.4 If new traffic actuated controllers and controller cabinets are called for on plans, the CONTRACTOR shall provide controllers and cabinets made by the same manufacturer.

429.4 CONSTRUCTION REQUIREMENTS.

429.4.1 Traffic signal controller cabinets shall normally be installed on concrete bases in the location shown on the plans or as directed by the ENGINEER. The cabinet door shall face away from the street unless otherwise specified on the plans. Upon installation of a ground mounted controller cabinet, the necessary grout or caulking shall be placed between cabinet and concrete base to provide a weather-resistant, dust-tight installation.

429.4.2 Should the CONTRACTOR find it necessary at a certain traffic signal system installation to provide a controller cabinet which is to large to be mounted on the type mounting arrangement as shown on the plans, he shall immediately notify the ENGINEER that a mounting change is necessary. This notification shall be prior to the pouring of the base as shown on the plans. The CONTRACTOR shall provide the proper mounting hardware and mount the controller cabinet as directed by the ENGINEER.

429.4.3 No conduit entry shall be made into the side of the cabinet unless otherwise called for on the plans or approved by the ENGINEER.

429.4.4 TESTING

429.4.4.1 The CONTRACTOR shall have the controllers and cabinets, and any specified auxiliary equipment transported to Traffic Engineering Operations Division, Pino Yard, City of Albuquerque with appropriate written documentation including project identification, signal plan sheets, operator manuals, and transmittal letter. These items will be delivered no less than 60 days prior to the ENGINEER's acceptance of compliance and the equipment will be tested for a minimum of 30 days of the 60 day period. The controller and cabinet furnished at this time shall be capable of operation with all load outputs and shall be complete in accordance with the plans, including any auxiliary equipment.

429.4.4.2 The controller may be subjected to inspection and testing as follows:

429.4.4.2.1 Visual inspection for compliance with contract requirements, arrangement of equipment, specified markings, and workmanship.

429.4.4.2.2 Operational Testing.

1. Specified phasing.
2. Various timings.
3. Indicators.
4. Pedestrian phasing.
5. Auxiliary functions and interconnects.
6. Flash mode.
7. All possible conflicts for fail safe.
8. Preemption interruption with every function and phase, when applicable.
9. Load switches at 1800 watts.
10. Interrupted power test.
11. Timings and operation at input voltage of 105 and 130 VAC.
12. Ambient temperature of 160 degrees F + 5 degrees F for a maximum period of 14 days.

429.4.4.2.3 The controller will be deemed to have failed to comply with these specifications if, as a result of the above mentioned tests, its operation or component parts are affected in any manner.

429.4.4.2.4 In the event of a component failure all testing will be stopped, and the CONTRACTOR will be so notified. It will then be the CONTRACTOR's responsibility to provide for the disposition or repair of the controller. The CONTRACTOR may submit new or repaired equipment for testing, and the ENGINEER will determine

the length of this new test period up to 30 days.

429.4.4.2.5 Upon notification of completion of the lab test and acceptance, the CONTRACTOR shall transport the controller and cabinet from the Pino Yard to the project site.

429.4.4.2.6 In addition to the lab tests, final acceptance of all controllers and cabinets shall occur as specified in Section 420 - General Clauses for Traffic Signal and Street Lighting Systems.

429.4.5 TURN ON

429.4.5.1 The turn on of all controllers and auxiliary equipment after installation shall be made only after the entire signal system has been inspected and approved by the ENGINEER and the Traffic Engineer. The CONTRACTOR shall give the ENGINEER, and the Traffic Engineer at least five (5) working days advanced written notice of the anticipated turn-on time. Personnel of Traffic Engineering Operations Division shall be present during turn on. The CONTRACTOR shall remove any conflicting traffic control signing as directed by the ENGINEER.

429.4.5.2 When called for on the plans, the CONTRACTOR shall arrange for a qualified manufacturer's representative to be present at the turn-on and/or to conduct a prepared school for new or special control equipment. The time and location shall be as specified on the plans.

429.4.6 MODIFICATIONS: Modifications and/or added equipment to an existing cabinet shall be made by a qualified signal manufacturer's representative. Cabinet wiring diagrams will be available at Traffic Engineering Operations Division, Pino Yard, City of Albuquerque or as noted on the plans. The proposed modifications to these wiring diagrams shall be returned and approved by the ENGINEER before any cabinet modification work is started. All work shall be inspected by the Traffic Engineer or his delegated representative(s) before the system is re-energized.

429.4.7 REMOVE AND RESET SIGNAL CONTROLLER: Remove and Reset Signal Controller. The CONTRACTOR shall disconnect existing signal controller from the existing controller cabinet, relocate the controller to the location shown on the plans, and reinstall the controller in a new or used controller cabinet.

429.4.8 REMOVE AND RESET SIGNAL CONTROLLER CABINET: The CONTRACTOR shall construct new foundations for the signal controller cabinet. The CONTRACTOR shall then remove existing signal controller cabinet and relocate the signal controller cabinet to the new foundations. All field wiring including loop lead-in cables, power, pedestrian pushbuttons, and signals shall be reconnected to provide a complete and operational signal.

429.5 MEASUREMENT AND PAYMENT.

429.5.1 Traffic actuated controllers, system masters, four phase single ring controller cabinets, eight phase dual ring controller cabinets, including all associated auxiliary equipment, will be measured by the unit of each type specified, complete in place.

429.5.2 Removing and resetting signal controllers and cabinets will be measured by the unit of each type specified, complete in place.

429.5.3 The accepted quantities of traffic actuated controllers system masters, four phase single ring controller cabinets, eight phase duel ring controller cabinets and removing and resetting signal controllers and cabinets will be paid for at the contract unit price per unit of measurement for each of the pay items listed as shown on the bid proposal.